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Bescheinigung

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The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

00201505.5

Der Präsident des Europäischen Patentamts;  
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets  
p.o.

I.L.C. HATTEN-HECKMAN

DEN HAAG, DEN  
THE HAGUE, 13/11/00  
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**Blatt 2 der Bescheinigung  
Sheet 2 of the certificate  
Page 2 de l'attestation**

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Demande n°: 00201505.5

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Anmelder:  
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Demandeur(s):  
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Video compression arrangement and method

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Video compression arrangement and method.

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## FIELD OF THE INVENTION

The invention relates to a method of compressing a video signal, comprising the steps of predictively encoding frames of said video signal with reference to a prediction frame, calculating for each encoded frame a quantization parameter, and quantizing the encoded frames in accordance with said quantization parameter.

## BACKGROUND OF THE INVENTION

A video compression method as defined in the opening paragraph has been standardized by the Motion Frames Expert Group and is well-known as MPEG1 or MPEG2. The known method includes transformation of video pixels into frequency coefficients, quantization of said coefficients, and variable-length coding of the quantized coefficients. The quantization is controlled so as to achieve a desired quality or bit rate of the compressed signal.

The MPEG compression method produces I-, P- and B-frames. I-frames are encoded autonomously, i.e. without reference to another frame. P-frames are predictively encoded with reference to a previous (possibly motion-compensated) I- or P-frame. B-frames are bidirectionally predictively encoded with reference to a previous and a subsequent I- or P-frame. B-frames are not themselves used as reference for encoding of other frames.

The concept of B-frames in MPEG provides maximum encoding efficiency. However, the use of B-frames roughly doubles the complexity, memory capacity and memory bandwidth. In view hereof, MPEG encoders have been developed which produce I- and P-frames only ("IP encoders"). A disadvantage of IP encoders is their efficiency. They need approximately 10-20% more bit rate than IPB encoders.

## OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an arrangement and method which overcomes the above mentioned disadvantage of prior art IP encoders.

To this end, the invention provides a video compression arrangement and method as defined in the independent claims. Advantageous embodiments are defined in the dependent claims.

The method in accordance with the invention quantizes selected P-frames more coarsely than other P-frames. This reduces the bit cost but degrades the image quality of said frames. The invention has a surprising effect. It was expected that the corresponding gain in bit cost would be lost in subsequent P-frames because the lower quality frames are used as prediction for subsequent P-frames. However, experiments have shown that this is not the case. It has been found that an IPPPP.. sequence of frames in which the quantization parameter of every other P-frame is multiplied by a factor of 1.4 has substantially the same bit rate as a conventional IBPBP.. sequence having the same perceptual visual quality. In view hereof, the lower quality P-frames are also referred to as "virtual B-frames".

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic diagram of an arrangement for compressing a video signal encoder in accordance with the invention.

Figs. 2A and 2B show diagrams illustrating the performance of the arrangement in accordance with the invention compared with the performance of a prior art arrangement.

## DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a schematic diagram of an MPEG encoder in accordance with the invention. The Figure shows the encoder in the state in which P-frames are encoded. The encoder is a conventional MPEG encoder in the sense that it comprises a subtraction circuit 10, a discrete cosine transformer (DCT) 11, a quantizer (Q) 12, a variable-length coder (VLC) 13, a buffer (BUF) 14, an inverse quantizer (iQ) 15, an inverse discrete cosine transformer (iDCT) 16, an adder 17, a frame memory (MEM) 18, a motion estimation and compensation circuit (ME/MC) 19, and a quantization adapter (QA) 20.

Briefly summarized, the known encoder operates as follows. The input video frame X is divided into blocks of  $8 \times 8$  pixels. The difference between each pixel block of input frame X and the corresponding block of a prediction frame  $X_p$  is discrete cosine transformed into a block of  $8 \times 8$  coefficients. The coefficients are subsequently quantized, by which perceptually irrelevant picture details are irreversibly removed (lossy compression). The quantized coefficients are variable-length encoded and stored in a buffer from which the

signal is applied to a transmission channel or record carrier. The encoded frame is locally decoded by inverse quantization, inverse discrete cosine transformation, and addition to the prediction frame  $X_p$ . The reconstructed frame is stored in the frame memory and subjected to motion estimation and compensation so as to constitute the prediction frame for the next input frame.

The encoder includes a quantization adapter **20** for calculating the quantization steps with which the DCT-coefficients are quantized. In this embodiment, the MPEG2 quantization mechanism is used in which a predetermined quantization matrix, which defines the step sizes to be applied to the respective coefficients of an  $8 \times 8$  coefficient block, is multiplied with a quantization scale factor  $q$  (herein further referred to as quantization parameter). The quantization parameter is adapted from frame to frame, but may be 'modulated' within a frame as a function of local image details. The quantization parameter may be controlled to represent a given image quality (resulting in a variable bit rate) or a given bit rate (resulting in variable quality). Various embodiments of quantization adapters (also referred to as bit rate controllers) are known in the art and may be employed in the encoder according to the invention.

The arrangement in accordance with the invention increases the quantization parameter  $q$  for selected frames, thereby degrading the image quality of said frames but reducing their bit costs. In this embodiment, the arrangement includes a multiplier **23** which multiplies the quantization parameter  $q$  calculated by the quantization adapter **20** with a predetermined factor  $F$  (e.g.  $F=1.4$ ). A switch **22** has a position  $P$  in which the conventional quantization parameter  $q$  is applied to the quantizer **12** and a position  $P'$  in which the coarser quantization parameter  $F \cdot q$  is applied to the quantizer. The switch is controlled by a control circuit **22** in a predetermined manner. For example, the control circuit selects every other P-frame to be more coarsely quantized.

Fig. 2A shows a diagram illustrating the performance of a conventional MPEG2 encoder which produces a stream of IPPP.. frames (no B-frames). Each frame is quantized in accordance with the quantization parameter  $q$  as calculated by the quantization adapter **20**. The lower row of figures denotes the bit cost of the respective frame, expressed as a percentage of the bit cost of the respective I-frame. The bit cost of P-frames appears to be 38% in this example.

Fig. 2B shows a similar diagram for an encoder in accordance with the invention. The quantization adapter **20** has been set to produce the same image quality as in Fig. 2A. In accordance herewith, the bit cost for I-frames is the same as in Fig. 2A. Every

other P-frame (denoted P' in the Figure) is now quantized with the quantization parameter 1.4q. The bit cost of the P'-frames is thereby reduced from 38% to 26%. The image quality of said frames is reduced in proportion therewith. The surprising effect of the invention is that the gain in bit cost is not lost in the subsequent 'conventional' P-frames. As shown in Fig. 2B, the bit cost of 'conventional' P-frames increases only from 38% to 42%. The net result is a considerable reduction of the bit rate at the same perceptual image quality (or a higher perceptual quality at the same bit rate) of the encoded video stream. In a practical experiment, the bit rate of a typical video signal was reduced from 15.2 Mbit/sec to 12.9 Mbit/sec at the same perceptual quality.

It is to be noted that the bit stream produced by an MPEG encoder in accordance with the invention fully complies with the MPEG standard. It should also be noted that although the invention has been described with reference to an IPP.. encoder (no B-frames), the invention does not exclude B-frame encoding. For example, an encoder may produce an IBPBP.. sequence in which selected P-frames have been quantized with the coarser quantization parameter. The coarser quantization parameter may even be applied to I-frames to the extent that such I-frames are used as prediction frame for subsequent frames.

The invention can be summarized as follows. The concept of B-frames gives the MPEG video compression standard its high encoding efficiency. However, B-frame encoding roughly doubles the complexity of an MPEG encoder. In view hereof, MPEG encoders have been developed which produce I-frames and P-frames only. They are less complex but also less efficient. To improve the efficiency of such "IPP encoders", selected P-frames are quantized more coarsely than other P-frames, for example, by multiplying the conventional quantization step size by 1.4. Although this results in isolated frames ("virtual B-frames") being encoded with a lower quality, the overall perceptual quality is not affected. It has been found that the gain in bit rate obtained by the coarser quantization is not lost in subsequent P-frames, even though the subsequent frames are encoded with reference to the lower quality frames.

CLAIMS:

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1. A method of compressing a video signal, comprising the steps of:

– predictively encoding (10,11) frames (X) of said video signal with reference to a prediction frame ( $X_p$ ),

– calculating (20) for each encoded frame a quantization parameter (q),

5 – quantizing (12) the encoded frames in accordance with said quantization parameter, characterized in that said step of calculating the quantization parameter includes calculating a first quantization parameter (q) representing a first quality or bit rate for quantizing selected first frames (P) of said predictively encoded frames, and a second quantization parameter (F.q) representing a second quality or bit rate lower than said first quality or bit rate for  
10 quantizing selected second frames (P') of the video signal, the method further including the step of decompressing (15-18) the compressed second frames to constitute the prediction frame ( $X_p$ ) for predictively encoding the first frames.

2. A method as claimed in claim 1, wherein the step of calculating the second

15 quantization parameter includes calculating said first quantization parameter (q) and multiplying (23) said first quantization parameter by a given factor (F).

3. A method as claimed in claim 1, wherein said predictively encoded frames constitute a series of successive frames, the second selected frames being every other frame  
20 of said series.

4. An arrangement for compressing a video signal, comprising:

– encoding means (10,11) for predictively encoding frames (X) of said video signal with reference to a prediction frame ( $X_p$ ),

25 – calculation means (20) for calculating for each encoded frame a quantization parameter (q),

– a quantizer (12) for quantizing the encoded frames in accordance with said quantization parameter,

characterized in that said calculation means (20) are arranged to calculate a first quantization parameter representing a first quality or bit rate for quantizing selected first frames (P) of said predictively encoded frames, and a second quantization parameter (F.q) representing a second quality or bit rate lower than said first quality or bit rate for quantizing selected second frames (P') of the video signal, the arrangement further including means (15-18) for decompressing the compressed second frames to constitute said prediction frame ( $X_p$ ) for predictively encoding first selected frames.

5. An arrangement as claimed in claim 4, wherein said calculation means (20) comprise a multiplier (23) for multiplying the first quantization parameter (q) by a given factor (F).

6. An arrangement as claimed in claim 4, wherein said predictively encoded frames constitute a series of successive frames, the second selected frames being every other frame of said series.

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ABST

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## ABSTRACT:

The concept of B-frames gives the MPEG video compression standard its high encoding efficiency. However, B-frame encoding roughly doubles the complexity of an MPEG encoder. In view hereof, MPEG encoders have been developed which produce I-frames and P-frames only. They are less complex but also less efficient. To improve the efficiency of such "IPP encoders", selected P-frames are quantized more coarsely than other P-frames, for example, by multiplying the conventional quantization step size by 1.4. Although this results in isolated frames ("virtual B-frames") being encoded with a lower quality, the overall perceptual quality is not affected. It has been found that the gain in bit rate obtained by the coarser quantization is not lost in subsequent P-frames, even though the subsequent frames are encoded with reference to the lower quality frames.

Fig. 1.

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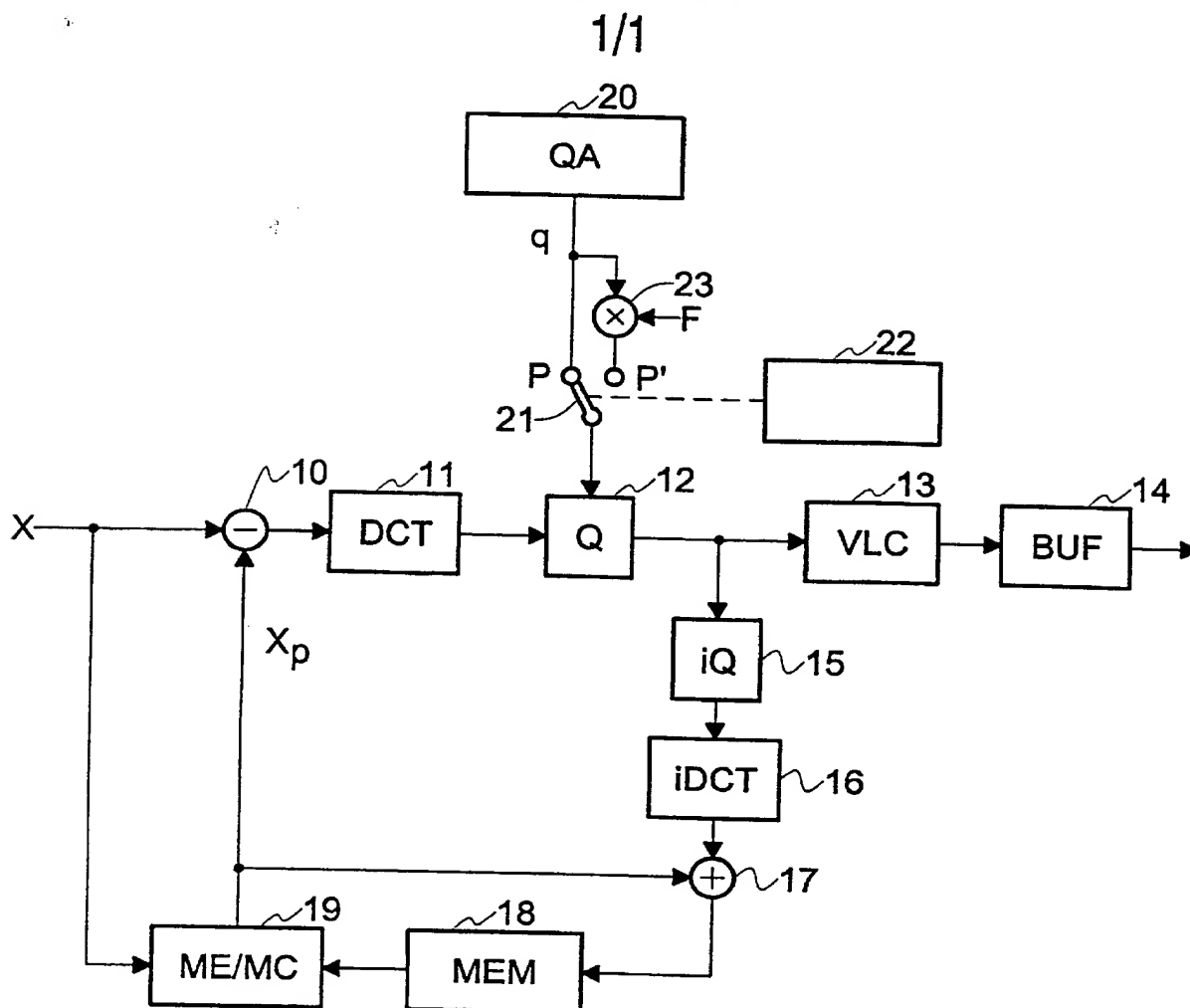


FIG. 1

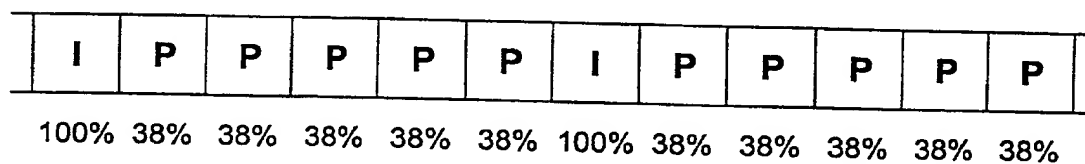


FIG. 2A

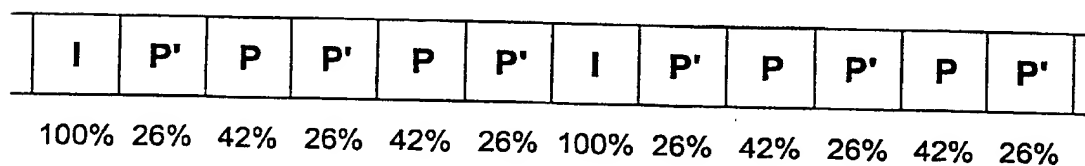


FIG. 2B

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